PROC. ENTOMOL. SOC. WASH.
92(2), 1990, pp. 274–281

DESCRIPTIONS OF THE FEMALES OF THREE *POLYCENTROPUS* SPECIES (TRICHOPTERA: POLYCENTROPODIDAE)

KEVIN M. HOFFMAN AND JOHN C. MORSE

Department of Entomology, Clemson University, Clemson, South Carolina 29634-0365.

Abstract.—The females of *Polycentropus blicklei* Ross and Yamamoto and *Polycentropus carlsoni* Morse are described and illustrated for the first time, and the female of *Polycentropus maculatus* Banks is redescribed and illustrated. Diagnoses are provided to distinguish these females both from each other and from those of other *Polycentropus* species in the *confusus* group. Some additional life-history information for *P. carlsoni* males is provided.

Key Words: Trichoptera, Polycentropodidae, *Polycentropus*, females, descriptions

The *confusus* group is one of five New World species groups within the genus *Polycentropus*, and contains fourteen named and one unnamed species (Hamilton 1986). The need for more associations of both females and larvae with the described males of the *confusus* group was stressed by Hamilton (1986), who reviewed but did not revise the group. To date, the females of eight species have been described, and larvae have been associated with but one species. The only key to females of the *confusus* group was provided by Ross (1944, pp. 63–64, couplets 21–26) for the females of seven species, one of which was not associated with males and was referred to as *Polycentropus* species a. The female of one other species, *Polycentropus neiswanderi* Ross, has been described in the intervening years (Ross 1947).

Polycentropus blicklei Ross and Yamamoto, *Polycentropus carlsoni* Morse, and *Polycentropus maculatus* Banks are all members of the *confusus* group. Both *P. blicklei* and *P. maculatus* have been reported from several states in the eastern United States as well as from provinces in eastern Canada (Hamilton 1986), while *P. carlsoni* has been reported from only three first to second order streams in the upper Piedmont of South Carolina and lower Valley and Ridge of Alabama (Morse 1971, Lago and Harris 1987). Of these three species, only the female of *P. maculatus* has been described (Ross 1944). The efforts to discover females of *P. blicklei* and *P. carlsoni* were in response to a preliminary review considering *P. carlsoni* for possible protection under the United States Endangered Species Act of 1973, as amended. The present paper describes the females of both *P. blicklei* and *P. carlsoni* for the first time, redescribes the female of *P. maculatus*, and provides additional life-history information on males of *P. carlsoni*.

MATERIALS AND METHODS

The associations of females with males of *P. blicklei* and *P. carlsoni* were accomplished in two steps. First, intensive collection efforts for adults were made during 1988 and early 1989 using Malaise traps at and near the type locality of *P. carlsoni*. Malaise traps similar to those described by Townes (1972) were deployed from April 1988 to

February 1989 at the type locality on Wildcat Creek (site 2, see below) and on four other nearby streams within the Clemson University Experimental Forest surrounding Lake Issaqueena, Pickens County, South Carolina. Trap collections were examined weekly until the end of August, biweekly from September to the end of November, and monthly from December 1988 to the end of February 1989. Locality data of the five sites and dates of trap operations are as follows: unnamed tributary of Indian Creek (site 1), elevation 230 m, 7 April to 27 June 1988; Wildcat Creek (site 2), elevation 235 m, 4 April 1988 to 28 February 1989; unnamed tributary #1 of Sixmile Creek (site 3), elevation 225 m, 5 April to 20 June 1988; unnamed tributary #2 of Sixmile Creek (site 4), elevation 220 m, 24 April 1988 to 28 February 1989; unnamed creek at Holly Springs Picnic Area (site 5), elevation 220 m, 5 April 1988 to 28 February 1989.

In addition, five localities on streams surrounding Lake Issaqueena were sampled during May 1988 using an Ellisco® light trap with a 15-watt ultraviolet bulb. The trap was operated for a two hour period following sunset. The five localities and dates of sampling are as follows: site 5 on 8 May, Sixmile Creek on 11 May, site 4 on 20 May, site 2 on 21 May, and an unnamed first order stream on 22 May.

The second step consisted of identifying *Polycentropus* females by using the key provided by Ross (1944) and by comparing undetermined females with those associated with males during three previous surveys in South Carolina, North Carolina, and Georgia. One of these surveys was conducted on Upper Three Runs Creek and its tributaries on the Savannah River Site, Aiken County, South Carolina; another was conducted on the Lake Jocassee catchment in Oconee County, South Carolina, and Transylvania County, North Carolina; and the third survey was conducted at Spring Creek in Crawford County, Georgia. The methodology and results of the studies at Upper Three Runs Creek and Lake Jocassee catchment have been published elsewhere (Morse et al. 1980, 1989), while only partial results of the Spring Creek study have been published (Rothschild et al. 1986, Hamilton and Holzenthal 1986). The survey at Spring Creek was conducted from April to October 1983 and consisted of a Malaise trap operated continuously and supplemented by ultraviolet light trap collections two to three times each month. A number of additional specimens housed in the Clemson University Arthropod Collection (CUAC), Department of Entomology, were also examined, most notably those collected during a previous study at the type locality of *P. carlsoni* (Carlson 1971).

Specimens were examined under a Wild® M8 stereomicroscope. Measurements were taken using an ocular micrometer calibrated at 20× and are presented as a range followed by the number of specimens measured. External structures were described from uncleared specimens examined in 80% ethanol, while internal structures were described from abdomens cleared in hot 10% potassium hydroxide and examined in glycerin. Terminology of the wings follows that presented by Hamilton (1972) and Ross et al. (1982), while that of the female genitalia follows Nielsen (1980). Because so few data have been published on *P. carlsoni*, forewing lengths and flight periods of both genders are included below. All specimens examined were preserved in 80% ethanol and deposited in the CUAC.

Results and Discussion

The males of three species in the *confusus* group were collected during the survey around Lake Issaqueena. These males were *P. blicklei*, *P. carlsoni*, and *Polycentropus confusus* Hagen. Collected females belonging to the *confusus* group keyed to either *P. confusus* or *P. maculatus* when using the key provided by Ross (1944). Females of *P. confusus* were easily distinguished using the figure in Ross (1944, fig. 257) and are not con-

sidered further. Examination of the genitalia of those females which keyed to *P. maculatus* revealed two distinct forms, both of which were different from *P. maculatus* females collected during the Lake Jocassee catchment survey. The assignment of one of these two forms to *P. blicklei* was accomplished by comparison of the genitalia with those of females previously collected with *P. blicklei* males at localities where no males of either *P. carlsoni* or *P. maculatus* were collected. The studies at Upper Three Runs Creek and Spring Creek provided such sites, and females from those localities had been previously identified tentatively as *P. blicklei* by S. W. Hamilton and one of us (JCM). Females in the remaining group of maculatus-like individuals were therefore concluded to be females of *P. carlsoni*. Females of *P. blicklei*, *P. carlsoni*, and *P. maculatus* can be distinguished from those of other species in the *confusus* group by the elongate, parallel to subparallel, internal parts of gonopods VIII (Figs. 1, 5, 9), which are visible in uncleared specimens through venter VIII.

Polycentropus blicklei Ross and Yamamoto, 1965

Figs. 1–4

Coloration (in alcohol).—Eyes purple, glazed; dorsum of head, prothorax, mesothorax, and tegulae brown with erect brown to pale yellow setae; antennae, mouthparts, remainder of thorax, and legs brown to pale yellow, femora, tibiae, and tarsi with brown setae; abdominal sclerites light brown, membrane dull white. Wing membranes and veins light brown, with scattered brown setae; forewing with s-m, m, basal fork of M, m-cu, and terminal end of P clear-white, forewing margin lacking setae in spots, appearing mottled; hind wing with s-m, basal fork of M, and m-cu clear-white.

Forewing length.—Females 5.1–8.6 mm (n = 70).

Female genitalia (Figs. 1–4).—Venter VIII with ventral plates (v.pl.) narrow, blade-like, tapering apically (Fig. 1); external parts of gonopods VIII darkly sclerotized in narrow crescent anteriorly (e.gon.VIIIb), transparent posteriorly (e.gon.VIIIa) with posterior margin triangular and rounded mesally; lateral margins comprised of portions of segment IX (IXb + IXc), darkly sclerotized to ¾ length. Internal vaginal apparatus mostly comprised of "cushion" (Fig. 3) involving internal parts of gonopods VIII (i.gon.VIII), external parts of gonopods IX (e.gon.IX), and internal portion of segment X (Xd) (Nielsen 1980). Internal parts of gonopods VIII (i.gon.VIII) dark, nearly parallel, elliptical, visible through venter VIII (Fig. 1); anterior ends oblique, extending to darkly sclerotized external part of gonopods VIII (e.gon.VIIIb) at basal third of ventral plates (Fig. 1) and to base of internal portion of segment X (Fig. 3); posterior ends acute, falling distinctly short of apices of ventral plates (Fig. 1); ventral surfaces longitudinally wrinkled. External parts of gonopods IX (e.gon.IX) weakly sclerotized, not fused with internal portion of segment X (Fig. 3). Internal portion of segment X (Xd) extending anteriad only to anterior margin of tergum IX (Nielsen 1980, fig. 22, d.IX), with sclerotized lateral plates widely separated, each with rounded transverse medial projection extending nearly to midline (Fig. 2). Anterior part of genital chamber (g.ch.a.) sclerotized, semicircular, attached by postero-dorsal membranes to antero-ventral edge of internal portion of segment X (Fig. 3, Xd); trough-like with concavity extending full length of postero-ventral surface. Processus spermathecae (p.sp.) ovoid with clear central elevation bearing opening of ductus spermathecae (op.dt.sp.) (Fig. 4), ventral and lateral margins enclosed by anterior part of genital chamber.

Diagnosis.—Females of *P. blicklei* are distinguishable externally from those of both *P. carlsoni* and *P. maculatus* by the extension of the internal parts of gonopods VIII (visible through venter VIII) only to the basal third of the ventral plates of venter VIII

and from those of *P. carlsoni* by the darkly sclerotized lateral edges of venter VIII. Internally, the short, widely separated lateral plates of the internal portion of segment X and the internal parts of gonopods VIII being as long as these plates are both diagnostic.

Notes.—Females were collected from 12 April to 8 November both at ultraviolet lights and in Malaise traps.

Material examined.—GEORGIA: Crawford County: Spring Creek, approx. 5 mi SSE of Roberta, 7–12.v.1983, 1 ♀; same data, 11.v.1983, 1 ♀; same data, 21–28.v.1983, 2 ♀; same data, 10.vi.1983, 1 ♀; same data, 11–30.vi.1983, 1 ♀; same data, 8.ix.1983, 1 ♀; same data, 20.x.1983, 3 ♀; RHODE ISLAND: Richmond, 20.vi.1971, 2 ♀; same data, 30.vi.1971, 1 ♀; SOUTH CAROLINA: Aiken County: Savannah River Plant, Upper Three Runs Creek, 12.iv.1977, 1 ♀; same data, 8.vii.1977, 1 ♀; Anderson County: Pendleton, Aldwood, 1.v.1976, 1 ♀; Pendleton, Tanglewood Spring, springbrook and disturbed site, 225 m el., 30.iv.1988; 6 ♀; same data, 9.v.1988, 5 ♀; same data, 17.vi.1987, 1 ♀; same data, 30.viii.1987, 1 ♀; same data, 3.xi.1987, 1 ♀; Oconee County: Salem, Burgess Creek, 28.ix.1969, 1 ♀; Pickens County: Clemson University Experimental Forest surrounding Lake Issaqueena, sites 1–5 and an unnamed creek, 13.iv.1968, 1 ♀; same data, 14.iv.1968, 1 ♀; same data, 17.iv.1968, 1 ♀; same data, 20.iv.1968, 3 ♀; same data, 23.iv.1968, 1 ♀; same data, 24.iv.1968, 2 ♀; same data, 24.iv.–1.v.1988, 1 ♀; same data, 26.iv.1968, 3 ♀; same data, 27.iv.1968, 1 ♀; same data, 6.v.1968, 1 ♀; same data, 8–15.v.1988, 2 ♀; same data, 9.v.1968, 1 ♀; same data, 15–22.v.1988, 1 ♀; same data, 18.v.1968, 1 ♀; same data, 21.v.1988, 2 ♀; same data, 22.v.1968, 1 ♀; same data, 22.v.1988; 2 ♀; same data, 23.v.1968, 1 ♀; same data, 27.v.1968, 1 ♀; same data, 28.v.1968, 1 ♀; same data, 30.v.1968, 1 ♀; same data, 30.v.–5.vi.1988, 1 ♀; same data, 5–12.vi.1988, 3 ♀; same data, 20–27.vi.1988, 1 ♀; same data, 2.ix.1968, 1 ♀; same data, 19.ix.1968, 1 ♀; same data, 21.ix.1968, 1 ♀; same data, 26.x.–8.xi.1988, 1 ♀; Keowee-Toxaway State Park, unnamed creek, 255 m el., 19.vi.1988, 2 ♀.

Polycentropus carlsoni Morse, 1971
Figs. 5–8

Coloration (in alcohol).—Eyes purple, glazed; dorsum of head, prothorax, mesothorax, and tegulae brown with erect brown to pale yellow setae; antennae, mouthparts, remainder of thorax, and legs brown to pale yellow, femora, tibiae, and tarsi with brown setae; abdominal sclerites light brown, membrane dull white. Wing membranes and veins light brown, with scattered brown setae; forewing with s-m, m, basal fork of M, m-cu, and terminal end of P clear-white, forewing margin lacking setae in spots, appearing mottled; hind wing with s-m, basal fork of M, and m-cu clear-white.

Forewing length.—Males 4.7–6.0 mm (n = 20), females 4.5–7.3 mm (n = 35).

Female genitalia (Figs. 5–8).—Venter VIII with ventral plates narrow, blade-like, tapering apically (Fig. 5); external parts of gonopods VIII darkly sclerotized in narrow crescent anteriorly, transparent posteriorly with posterior margin triangular and rounded mesally; lateral margins not conspicuously darkened. Internal parts of gonopods VIII dark, parallel, rectangular; anterior ends oblique, extending to darkly sclerotized part of external gonopods VIII at basal fourth of ventral plates (Fig. 5) and to basal third of internal portion of segment X (Fig. 7); posterior ends oblique, falling distinctly short of apices of ventral plates (Fig. 5); ventral surfaces longitudinally wrinkled, sometimes with groove extending entire length of surface. External parts of gonopods IX fused with internal portion of segment X (Fig. 7). Internal portion of segment X extending anteriad only slightly into segment VII, nearly solid sclerite dorsally except for inconspicuous triangular opening medially (Fig. 6), anterior margin darkly rebordered and narrowly cleft medially, posterior margin inconspicuous and notched medially.

Sclerotized anterior part of genital chamber attached by postero-dorsal membranes to antero-ventral edge of internal portion of segment X (Fig. 7). Processus spermathecae ovoid with clear central elevation bearing opening of ductus spermathecae (Fig. 8), ventral and lateral margins enclosed by anterior part of genital chamber.

Diagnosis.—Females of *P. carlsoni* are distinguished externally from those of *P. blicklei* by the extension of the internal parts of gonopods VIII to the basal fourth of the ventral plates of venter VIII and from those of *P. maculatus* by the unpigmented lateral margins of venter VIII. Internally, the following characters are diagnostic: the darkly rebordered anterior margin and narrow medial cleft of the internal portion of segment X, the extension of the internal portion of segment X to the anterior margin of tergum VIII, and (like *P. maculatus*) the extension of the internal parts of gonopods VIII only to the anterior third of the internal portion of segment X.

Notes.—Males were captured from 20 April to 26 October, while females were captured from 15 April to 8 November. All specimens examined were captured in Malaise or modified emergence traps on first to second order streams in mixed hardwood-pine forests at elevations between 215 and 245 meters. The only collections of this species at ultraviolet lights were of two males in Alabama (Lago and Harris 1987).

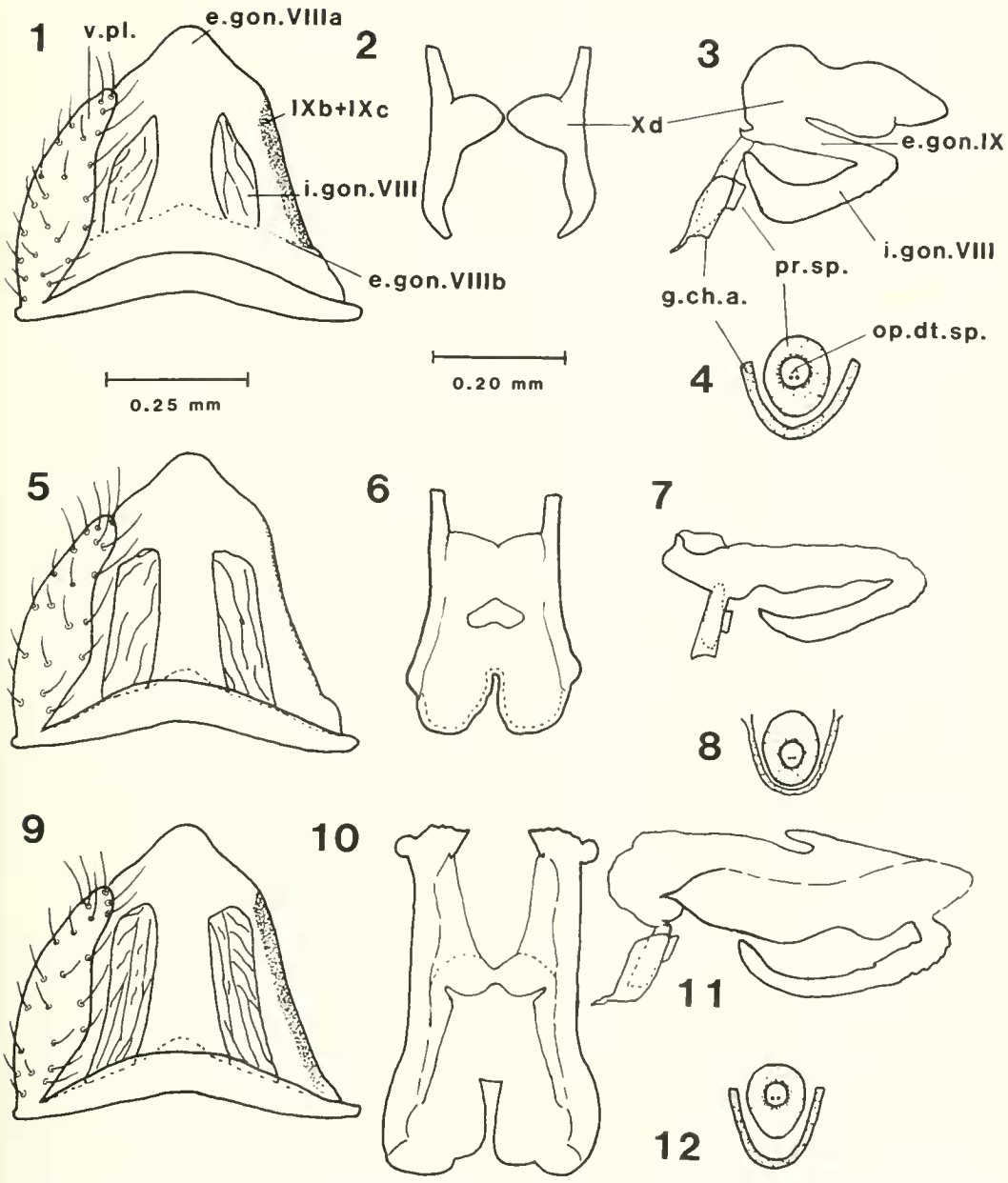
Material examined.—SOUTH CAROLINA: Anderson County: Pendleton, Tanglewood Spring, springbrook, 17–24.vi.1987, 1 ♀; same data, 15–22.vii.1987, 1 ♀; Pickens County: Clemson University Experimental Forest surrounding Lake Issaqueena, sites 1–5, 15.iv.1968, 1 ♀; same data, 20.iv.1968, 2 ♂; same data, 24.iv.1968, 1 ♀; same data, 24.iv.–1.v.1988, 1 ♂; same data, 12.v.1968, 1 ♀; same data, 15–22.v.1988, 1 ♀; same data, 22–30.v.1988, 1 ♂; same data, 30.v.–5.vi.1988, 4 ♀; same data, 5–12.vi.1988, 3 ♂ and 4 ♀; same data, 12–20.vi.1988, 6 ♂ and 2 ♀; same data, 20–27.vi.1988, 1 ♂ and 1 ♀; same data, 27.vi–4.vii.1988, 2 ♂ and 3 ♀; same data, 4–11.vii.1988, 3 ♀; same data, 11–18.vii.1988, 1 ♂ and 5 ♀; same data, 18–25.vii.1988, 1 ♀; same data, 27.vii.–1.viii.1988, 1 ♀; same data, 8–15.viii.1988, 1 ♀; same data, 15–22.viii.1988, 1 ♂; same data, 31.viii.–18.ix.1988, 1 ♂, same data, 18–26.ix.1988, 1 ♀; same data, 6–13.x.1988, 1 ♀; same data, 13–26.x.1988, 1 ♂ and 1 ♀; same data, 26.x.–8.xi.1988, 1 ♀.

Polycentropus maculatus Banks, 1908
Figs. 9–12

Coloration (in alcohol).—Eyes purple, glazed; dorsum of head, prothorax, mesothorax, and tegulae brown with erect brown to pale yellow setae; antennae, mouthparts, remainder of thorax, and legs brown to pale yellow, femora, tibiae, and tarsi with brown setae; abdominal sclerites light brown, membrane dull white. Wing membranes and veins light brown, with scattered brown setae; forewing with s-m, m, basal fork of M, m-cu, and terminal end of P clear-white, forewing margin lacking setae in spots, appearing mottled; hind wing with s-m, basal fork of M, and m-cu clear-white.

Forewing length.—Females 5.3–8.5 mm (n = 15).

Female genitalia (Figs. 9–12).—Venter VIII with ventral plates narrow, blade-like, tapering apically (Fig. 9); external parts of gonopods VIII darkly sclerotized in narrow crescent anteriorly, transparent posteriorly with posterior margin triangular and rounded mesally; lateral margins darkly sclerotized to ¾ length. Internal parts of gonopods VIII dark, subparallel, rectangular; anterior ends oblique, extending to darkly sclerotized part of external gonopods VIII at basal fourth of ventral plates (Fig. 9) and to basal third of internal portion of segment X (Fig. 11); posterior ends oblique, extending nearly to apices of ventral plates (Fig. 9); ventral surfaces longitudinally wrinkled, with groove extending entire length of surface. External parts of gonopods IX fused with



Figs. 1–12. Female genitalia of *Polycentropus* spp. *P. blicklei:* 1, venter VIII with right ventral plate removed, ventral view. 2, internal portion of segment X, dorsal view. 3, internal genitalia, left lateral view. 4, processus spermathecae and anterior part of genital chamber, caudo-ventral view. *P. carlsoni:* 5, venter VIII with right ventral plate removed, ventral view. 6, internal portion of segment X, dorsal view. 7, internal genitalia, left lateral view. 8, processus spermathecae and anterior part of genital chamber, caudo-ventral view. *P. maculatus:* 9, venter VIII with right ventral plate removed, ventral view. 10, internal portion of segment X, dorsal view. 11, internal genitalia, left lateral view. 12, processus spermathecae and anterior part of genital chamber, caudo-ventral view. v.pl. = ventral plates, e.gon.VIIIa and e.gon.VIIIb = external parts of gonopods VIII, i.gon.VIII = internal parts of gonopods VIII, IXb + IXc = portions of segment IX, e.gon.IX = external parts of gonopods IX, Xd = internal portion of segment X, g.ch.a. = anterior part of genital chamber, op.dt.sp. = opening of ductus spermathecae, pr.sp. = processus spermathecae.

internal portion of segment X and forming conspicuous twisted flange anteriorly (Figs. 10, 11). Internal portion of segment X extending anteriad halfway through segment VII and fused medially (Fig. 10), anterior margin inconspicuous and narrowly cleft medially, postero-medial margin recurved anteriorly and forming pocket. Sclerotized anterior part of genital chamber attached by postero-dorsal membranes to antero-ventral edge of internal portion of segment X (Fig. 11). Processus spermathecae ovoid with clear central elevation bearing opening of ductus spermathecae (Fig. 12), ventral and lateral margins enclosed by anterior part of genital chamber.

Diagnosis.—Females of *P. maculatus* are distinguished externally from those of *P. blicklei* by the extension of the internal parts of gonopods VIII to the basal fourth of the ventral plates of venter VIII and from those of *P. carlsoni* by the darkly pigmented lateral margins of venter VIII. Internally, the following characters are diagnostic: the deep, narrow, nonrebordered antero-medial cleft of the internal portion of segment X; the extension of the internal portion of segment X anteriorly to the middle of abdominal segment VII; the conspicuous, twisted antero-lateral flanges of the internal portion of segment X; and (like *P. carlsoni*) the extension of the internal parts of gonopods VIII only to the anterior third of the internal portion of segment X.

Notes.—Females were collected from 18 May to 15 September at ultraviolet lights and in Malaise traps.

Material examined.—GEORGIA: Union County: Vogel State Park, Wolf Creek, 22.vii.1972, 1 ♀; NORTH CAROLINA: Transylvania County: Bearcamp Creek at 420 m el., 20–21.vii.1987, 2 ♀; SOUTH CAROLINA: Oconee County: Coley Creek at 420 m el., 20–21.vii.1987, 2 ♀; same data, 14–15.ix.1987, 3 ♀; E. Fork Chattooga River, U.S. Fish Hatchery, 13.vii.1969, 2 ♀; Thompson River at NC border, ca. 420 m el., 18–19.v.1987, 1 ♀; same data, 15–16.vi.1987, 1 ♀; Pickens County: Rocky Bottom, Eastatoe Creek, 5.vii.1969, 3 ♀; Table Rock, Carrick Creek, 10.viii.1969, 1 ♀.

The similarity of the females of *P. blicklei, P. carlsoni,* and *P. maculatus* reinforces the close relationships between these species alluded to in the original descriptions of the males of both *P. blicklei* and *P. carlsoni.* Ross and Yamamoto (1965) compared and contrasted the male genitalia of *P. blicklei* with those of *P. maculatus,* and Morse (1971) stated that males of *P. carlsoni* most closely resembled those of *P. blicklei.* However, characters of the female genitalia point to a closer relationship between *P. carlsoni* and *P. maculatus* than between either of these and *P. blicklei.* The long, medially-fused internal portion of segment X; the deep, narrow antero-medial cleft of this structure; and the long rectangular internal parts of gonopods VIII appear to be homologues unique to the former two species. Thus, characters of the female genitalia may well prove useful in constructing a phylogeny for the *confusus* group and may add significantly to phylogenetic analyses of other New World species groups of *Polycentropus* as well.

Acknowledgments

We thank Steven W. Hamilton (Austin Peay State University, Tennessee) for both information on the Spring Creek study and advice on morphological terminology, and Steve C. Harris (University of Alabama, Tuscaloosa) for information regarding the Alabama collection localities of *P. carlsoni.* Gratitude is extended to Joseph D. Culin, John A. DuRant (both of Clemson University), and one anonymous reviewer for their helpful comments on this manuscript. This study was funded by a grant from the U.S. Fish and Wildlife Service and administered by the South Carolina Wildlife and Marine Resources Department, and this support is gratefully acknowledged. This is Technical Contribution No. 2981 of the South Caro-

lina Agricultural Experiment Station, Clemson University.

Literature Cited

Banks, N. 1908. Some Trichoptera, and allied insects, from Newfoundland. Psyche 15: 61–67.

Carlson, P. H. 1971. Emergence and seasonal distribution of Ephemeroptera from Wildcat Creek, Pickens County, South Carolina. M.S. thesis, Clemson Univ., Clemson, South Carolina.

Hamilton, K. G. A. 1972. The insect wing, part III. Venation of the orders. J. Kans. Entomol. Soc. 45: 145–162.

Hamilton, S. W. 1986. Systematics and biogeography of the New World *Polycentropus sensu stricto* (Trichoptera: Polycentropodidae). Ph.D. dissertation, Clemson Univ., Clemson, South Carolina.

Hamilton, S. W. and R. W. Holzenthal. 1986. Two new species of caddisflies from Georgia (Trichoptera: Polycentropodidae, Hydroptilidae). Proc. Entomol. Soc. Wash. 88: 163–166.

Lago, P. K. and S. C. Harris. 1987. An annotated list of the Curvipalpia (Trichoptera) of Alabama. Entomol. News 98: 255–262.

Morse, J. C. 1971. New caddisflies (Trichoptera) from the southeastern United States. J. Ga. Entomol. Soc. 6: 77–84.

Morse, J. C., J. W. Chapin, D. D. Herlong, and R. S. Harvey. 1980. Aquatic insects of Upper Three Runs Creek, Savannah River Plant, South Carolina. Part I: Orders other than Diptera. J. Ga. Entomol. Soc. 15: 73–101.

Morse, J. C., S. W. Hamilton, and K. M. Hoffman. 1989. Aquatic insects of Lake Jocassee catchment in North and South Carolina, with descriptions of four new species of caddisflies (Trichoptera). J. Elisha Mitchell Sci. Soc. 105: 14–33.

Nielsen, A. 1980. A comparative study of the genital segments and the genital chamber in female Trichoptera. Biol. Skr. Udgivet K. Dan. Vidensk. Selsk. 23: 1–200.

Ross, H. H. 1944. The caddis flies or Trichoptera of Illinois. Ill. Nat. Hist. Surv. Bull. 23: 1–326.

———. 1947. Descriptions and records of North American Trichoptera, with synoptic notes. Trans. Am. Entomol. Soc. 73: 125–168.

Ross, H. H., C. A. Ross, and J. R. P. Ross. 1982. A textbook of entomology, 4th ed. Wiley, New York.

Ross, H. H. and T. Yamamoto. 1965. New species of caddisfly genus *Polycentropus* from eastern North America (Trichoptera, Psychomyiidae). Proc. Biol. Sci. Wash. 78: 241–246.

Rothschild, M., R. W. Holzenthal, and S. W. Hamilton. 1986. The diversity and phenology of Trichoptera from Spring Creek, Georgia. Bull. North Am. Benthol. Soc. 3(2): 68 (abstr.).

Townes, H. 1972. A light-weight Malaise trap. Entomol. News 83: 239–247.